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Patent and Trademark Office: U.S DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	273012008102	*Total Pages*	2
First Named Inventor or Application Identifier			
Narendra R. DESAI *et al.*			
Express Mail Label No.	N/A		

CERTIFICATE OF HAND DELIVERY

I hereby certify that this correspondence is being hand filed with the United States Patent and Trademark Office in Washington, D.C. on June 8, 2000.

R. Lynn Boyden

R. Lynn Boyden

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents**
Box Patent Application
Washington, DC 20231

1. [X] Fee Transmittal Form
   (Submit an original, and a duplicate for fee processing)
2. [X] Specification [*Total Pages* 32]
   (preferred arrangement set forth below)
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 USC 113)* [*Total Sheets* 4]
4. [X] Oath or Declaration [*Total Pages* 6]
   a. [ ] Newly executed (original or copy)
   b. [X] Copy from a prior application (37 CFR 1.63(d)
   (for continuation/divisional with Box 17 completed)
   [Note Box 5 below]
   i. [ ] DELETION OF INVENTOR(S)
   Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b)
5. [X] Incorporation By Reference *(useable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program *(Appendix)*
7. Nucleotide and/or Amino Acid Sequence Submission
   (if applicable, all necessary)
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [ ] Assignment Papers (cover sheet & document(s))
9. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
10. [ ] English Translation Document *(if applicable)*
11. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [X] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503)
    (Should be specifically itemized)
14. [ ] Small Entity Statement(s) [ ] Statement filed in prior application, Status still proper and desired
15. [ ] Certified Copy of Priority Document(s)
    (if foreign priority is claimed)
16. [ ] ....

17. If a CONTINUING APPLICATION, *check appropriate box and supply the requisite information:*

[X] Continuation [ ] Divisional [ ] Continuation-in-part (CIP)______________of prior application No: 08/489,850

18. CORRESPONDENCE ADDRESS

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☒ If a paper is untimely filed in the above-referenced application by applicant or his/her representative, the Assistant Commissioner is hereby petitioned under 37 C.F.R. § 1.136(a) for the minimum extension of time required to make said paper timely. In the event a petition for extension of time is made under the provisions of this paragraph, the Assistant Commissioner is hereby requested to charge any fee required under 37 C.F.R. § 1.17(a)-(d) to **Deposit Account No. 03-1952**. However, the Assistant Commissioner is **NOT** authorized to charge the cost of the issue fee to the Deposit Account.

The filing fee has been calculated as follows:

FOR	NUMBER FILED	NUMBER EXTRA	RATE	CALCULATIONS
TOTAL CLAIMS	18 - 20 =	0	x $18.00	$0.00
INDEPENDENT CLAIMS	1 - 3 =	0	x $78.00	$0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$0.00
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		TOTAL OF ABOVE CALCULATIONS =		$690.00
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Dated: June 8, 2000

Respectfully submitted,

By: [signature]

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R. Lynn Boyden

R. Lynn Boyden

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:

Narendra R. DESAI *et al.*

Serial No.: Continuation of 08/489,850

Filing Date: filed herewith

For: LIPOSOME COMPOSITIONS OF PORPHYRIN PHOTOSENSITIZERS

Examiner: Unassigned

Group Art Unit: Unassigned

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to examination of this application, please amend the application as follows:

In the specification:

On page 1, first line after title of the invention, please insert --This is a continuation of U.S. Patent Application Serial Number 08/489,850, filed June 13, 1995, now U.S. Patent No. 6,074,666, which is a continuation of U.S. Patent Application Serial Number 07/832,542, filed February 5, 1992, now abandoned.--

In the claims:

Please cancel claims 1-14.

Please enter the following new claims:

--15. A liposomal formulation comprising liposomes that comprise a porphyrin macrocycle photosensitizer and one or more sugars

wherein said liposomes are fast breaking and rapidly release the photosensitizer into the bloodstream upon *in vivo* administration.

16. The liposomal formulation of claim 15 in freeze-dried form.

17. The liposomal formulation of claim 15 wherein said sugars are selected from disaccharides or polysaccharides.

18. The liposomal formulation of claim 17 wherein said disaccharides are selected from lactose or trehalose.

19. The liposomal formulation of claim 15 wherein the lipid bilayer of said liposomes consists essentially of dimyristoyl phosphatidyl choline and egg phosphatidyl glycerol.

20. The liposomal formulation of claim 15 wherein said porphyrin macrocycle photosensitizer is a hydro-monobenzoporphyrin (Gp) of the formulas set forth in Figure 1-1 or 1-2 having a light absorption maximum between 670-780 nm, mixtures thereof, and the metalated and labeled forms thereof,

wherein each R^1 and R^2 is independently selected from the group consisting of carbalkoxy (2-6C), alkyl (1-6C) sulfonyl, aryl (6-10C) sulfonyl, aryl (6-10C); cyano; and -$CONR^5CO$- wherein R^5 is aryl (6-10C) or alkyl (1-6C);

each R^3 is independently carboxyalkyl (2-6C) or a salt, amide, ester or acylhydrazone thereof, or is alkyl (1-6C); and

R^4 is $-CH{=}CH_2$, $-CHOR^{4'}$, $-CHO$, $-COOR^{4'}$, $-CH(OR^{4'})CH_3$, $-CH(OR^{4'})CH_2OR^{4'}$, $-CH(SR^{4'})CH_3$, $-CH(NR^{4'}{}_2)CH_3$, $-CH(CN)CH_3$, $-CH(COOR^{4'})CH_3$, $-CH(OOCR^{4'})CH_3$, $-CH(halo)CH_3$, or $-CH(halo)CH_2(halo)$, wherein $R^{4'}$ is H, alkyl (1-6C) optionally substituted with a hydrophilic substituent,

an organic group of less than 12C resulting from direct or indirect derivatization of vinyl, or

1-3 tetrapyrrole-type nuclei of the formula -L-P wherein -L- is selected from the group consisting of:

```
-CH-O-CH-,    -CHNHCH-,    -CH=CH-CH-,
 |     |        |    |           |
 Me    Me       Me   Me          Me

    (a)           (b)            (c)

-CH-CH=CH-,   =CH-C-CH-,   and   -CH-C-CH=
 |                 ||  |           |  ||
 Me                O   Me          Me O

    (d)            (e)              (f)
```

and P is selected from the group consisting of Gp which is of the formula of Figure 1-2, but lacking R_4 and conjugated through the position shown as occupied by R^4 to L;

with the proviso that, if R^4 is -CH=CH2, both R^3 groups cannot be carbalkoxyethyl.

21. The liposomal formulation of claim 20 wherein each R^3 is $-CH_2CH_2COOH$ or salt, amide, ester or acylhydrazone thereof.

22. The liposomal formulation of claim 20 wherein each of R^1 and R^2 is carbalkoxy (2-6C).

23. The liposomal formulation of claim 21 wherein each of R^1 and R^2 is carbalkoxy (2-6C).

24. The liposomal formulation of claim 20 wherein said hydro-monobenzoporphyrin (Gp) is selected from the group consisting of:

BPD-DA wherein R^1 and R^2 thereof are carbomethoxy;

BPD-DB wherein R^1 and R^2 thereof are carbomethoxy;

BPD-MA wherein R^1 and R^2 thereof are carbomethoxy and R is methyl; and

BPD-MB wherein R^1 and R^2 thereof are carbomethoxy and R is methyl.

25. The liposomal formulation of claim 24 wherein said hydro-monobenzoporphyrin (Gp) is BPD-MA wherein R^1 and R^2 thereof are carbomethoxy and R is methyl.

26. The liposomal formulation of claim 19 wherein the amounts of photosensitizer, dimyristoyl phosphatidyl choline, and egg phosphatidyl glycerol in said liposomes are, relative to each other on a per weight basis, about

0.2 to 0.4 of porphyrin; 0.94 to 1.88 of dimyristoyl phosphatidyl choline; and 0.65 to 1.30 of egg phosphatidyl glycerol.

27. The liposomal formulation of claim 26 wherein the amount of sugar, relative to said amounts of photosensitizer, dimyristoyl phosphatidyl choline, and egg phosphatidyl glycerol in said liposomes on a per weight basis, about 8.0 to 12.0 of sugar when said sugar is a disaccharide, or about half that amount if said sugar is a monosaccharide.

28. The liposomal formulation of claim 19 further comprising an antioxidant.

29. The liposomal formulation of claim 28 wherein said antioxidant is butylated hydroxytoluene or L-ascorbic acid 6-palmitate.

30. The liposomal formulation of claim 15 further comprising a pharmaceutically acceptable excipient.

31. A method of providing photodynamic therapy to a subject comprising

administering a formulation according to claim 15 to said subject wherein the porphyrin macrocycle photosensitizer, after release from said formulation, is capable of localizing to target tissues or cells, and

irradiating said tissues or cells at an appropriate wavelength of light after passage of sufficient time for said porphyrin macrocycle photosensitizer to localize.

32. A method of providing photodynamic therapy to a subject comprising administering a formulation according to claim 19 to said subject wherein the porphyrin macrocycle photosensitizer, after release from said formulation, is capable of localizing to target tissues or cells, and

irradiating said tissues or cells at an appropriate wavelength of light after passage of sufficient time for said porphyrin macrocycle photosensitizer to localize.--

REMARKS

Support for new claims 15-32 is provided at least by the claims as originally filed and following: pages 9, 10, 12, 13, 24 and 25. No new matter has been added and entry of the amendment is respectfully requested.

In the event that the transmittal letter is separated from this document and the Patent Office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Assistant Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing docket no. 273012008102. However, the Assistant Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Dated: June 8, 2000

Respectfully submitted,

By: ______________

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LIPOSOME COMPOSITIONS OF PORPHYRIN PHOTOSENSITIZERS

Field of the Invention

The invention relates to improved pharmaceutical formulations comprising liposomes incorporating porphyrin photosensitizers. Specifically, the invention is directed to a freeze-dried pharmaceutical formulation comprised of a porphyrin photosensitizer, a disaccharide or polysaccharide and one or more phospholipids which, upon reconstitution with a suitable aqueous vehicle, forms liposomes containing the porphyrin photosensitizer. Particular porphyrin photosensitizers which are advantageously employed in the practice of this invention include the hydro-monobenzoporphyrins having a light absorption maxima in the range of 670-780 nanometers. The photosensitizing formulations are useful to mediate the destruction of unwanted cells or tissues or other undesirable materials by irradiation or to detect their presence through flourescence.

Description of the Related Art

The use of porphyrin compounds, and in particular hematoporphyrin and hematoporphyrin derivative (HPD), have been known for some time to be useful systemically when combined with light, for the treatment and diagnosis of malignant cells. The porphyrins appear to naturally "localize" in malignant tissue where they absorb light at certain wavelengths

when irradiated, providing a means to detect the tumor by the location of the fluorescence. Accordingly, preparations containing the porphyrins are useful in the diagnosis and detection of such tumor tissues. (See, e.g. "Porphyrin Photosensitization", Kessel, D., et al., eds. (1983) Plenum Press). In addition, the porphyrins also have the capability of exhibiting a cytotoxic effect on the cells or other tissues in which they are localized when exposed to light at the appropriate wavelength. (See, e.g., Diamond, I., et al., Lancet (1972) 2: 1175-1177; Dougherty, T.J. et al., "The Science of Photo Medicine" (1982) J.D. Regan & J.A. Parrish, eds., pp. 625-638; Dougherty, T.J., et al., "Cancer: Principles and Practice of Oncology" (1982) V.T. DeVita Jr., et al., eds., pp. 1836-1844). It has been postulated that the cytotoxic effect of the porphyrins is due to the formation of singlet oxygen when exposed to light (Weishaupt, K.R., et al., Cancer Research, (1976) 36: 2326-2329). The successful treatment of AIDS-related oral Kaposi's Sarcoma with a purified form of HPD, Photofrin® porfimer sodium, was described in Schwietzer, V.G. et al., Otolaryngology -- Head and Neck Surgery (1990) 102: 639-649.

In addition to systemic use for the treatment and diagnosis of tumors, the porphyrins can be used in a variety of other therapeutic applications. For example, photosensitizers are useful in the detection and treatment of artherosclerotic plaques as disclosed in U.S. Patent No. 4,517,762 and 4,577,636. U.S. Patent Nos. 4,500,507 and 4,485,806 describe the use of radiolabeled porphyrin compounds for tumor imaging. Porphyrin compounds have also been used topically to treat various skin diseases as disclosed in U.S. Patent No. 4,753,958.

A number of porphyrin photosensitizer preparations have been disclosed for therapeutic

applications. A photosensitizer preparation widely used in the early stages of photodynamic therapy both for detection and treatment was a crude derivative of hematoporphyrin, also called hematoporphyrin derivative (HPD) or Lipson derivative, prepared as described by Lipson et al., J. Natl. Cancer Inst. (1961) 26: 1-8. A purified form of the active component(s) of HPD was prepared by Dougherty and co-workers by adjustment of the pH to cause aggregation and recovery of the aggregate, as disclosed in U.S. Patents 4,649,151, 4,866,168, 4,889,129 and 4,932,934. A purified form of this product is used clinically under the trademark Photofrin® porfimer sodium. Of particular interest in the context of the present invention are a group of modified porphyrins, known as "green porphyrins" (Gp), having a light absorption maximum between 670-780nm which have been shown to confer cytotoxicity to target cells at concentrations lower than those required for hematoporphyrin or HPD. These Gp are obtained using Diels-Alder reactions of acetylene derivatives with protoporphyrin under appropriate conditions. The preferred forms of Gp are the hydro-monobenzoporphyrin derivatives ("BPD"). The preparation and use of the Gp and BPD compounds are disclosed in U.S. Patent 4,920,143 and U.S. Patent 4,883,790, hereby incorporated by reference into the disclosure of the present application.

While the porphyrin compounds naturally have the ability to localize in neoplastic tissue while being cleared from the normal surrounding tissue, the selectivity of the porphyrin sensitizers is somewhat limited. Because tumor tissues generally include various components such as malignant cells, the vascular system, macrophages, fibroblasts, etc., the distribution of the photosensitizer in the tissue may be highly heterogeneous, especially for those

photosensitizers which are not homogeneous and contain a mixture of components with different degrees of hydro or lipo-solubility. Zhou, C. et al., Photochemistry and Photobiology, (1988) 48: 487-492. The low selectivity of some of these tumors as tumor localizers may lead to side effects such as hypersensitivity exhibited nonspecifically throughout the organism. Therefore, an active area of research is to increase the tumor selectivity of known porphyrin photosensitizers and to identify those porphyrin photosensitizers which exhibit higher tumor-selectivity. In general, those photosensitizers which are more lipophilic tend to exhibit greater tumor targeting. J.D. Spikes, et al., Lasers in Medical Science, (1986) 2: 3, 3-15.

It has recently been shown that the encapsulation of certain drugs in liposomes before administration has a marked effect on the pharmacokinetics, tissue distribution, metabolism and efficacy of the therapeutic agent. Liposomes are completely closed lipid bilayer membranes containing an entrapped aqueous volume which are formed spontaneously on addition of an aqueous solution to a dry lipid film. They may be unilamellar vesicles possessing a single membrane bilayer or multilamellar vesicles having multiple membrane bilayers, each separated from the next by an aqueous layer. The bilayer is composed of two lipid monolayers having a hydrophobic "tail" region and a hydrophilic "head" region. The structure of the membrane bilayer is such that the hydrophobic (non polar) "tails" of the lipid monolayers orient towards the center of the bilayer while the hydrophilic "heads" orient toward the aqueous phase.

In a liposome-drug delivery system, a hydrophilic therapeutic agent is entrapped in the aqueous phase of the liposome and then administered to the patient. Alternatively, if the therapeutic agent

is lipophilic, it may associate with the lipid bilayer. Liposomes may be used to help "target" a drug to the active site or to solubilize hydrophobic drugs for administration.

In an effort to increase the tumor selectivity of porphyrin photosensitizers, the porphyrin compounds have been incorporated into unilamellar liposomes resulting in a larger accumulation and more prolonged retention of the photosensitizer by both cultured malignant cells and experimental tumors in vivo. Jori et al., Br. J. Cancer, (1983) 48: 307-309; Cozzani et al., In Porphyrins in Tumor Phototherapy, Andreoni et al., eds., (1984) pp. 177-183, Plenum Press. The more efficient targeting of tumor tissues by liposome-associated porphyrins may be partly due to the specific delivery of the phospholipid vesicles to serum lipoproteins, which have been shown to interact preferentially with hyperproliferative tissue such as tumors through receptor mediated endocytosis. In this manner the selectivity of porphyrin uptake by tumors is increased as compared with photosensitizers dissolved in aqueous solution. See Zhou et al., supra.

Accordingly, hematoporphyrin and hematoporphyrin dimethylester have been formulated in unilamellar vesicles of dipalmitoyl-phosphatidyl choline (DPPC) and liposomes of dimyristoyl (DMPC) and distearoyl-phosphatidyl choline (DSPC). Zhou et al., supra; Ricchelli, F., New Directions in Photodynamic Therapy, (1987) 847: 101-106; Milanesi, C., Int. J. Radiat. Biol., (1989) 55: 59-69. Similarly, HP, Photofrin® porfimer sodium, and tetrabenzo-porphyrins have been formulated in liposomes composed of egg phosphatidyl choline (EPC). Johnson, F.M. et., Proc. Photodynamic Therapy: Mechanisms II, (1990), Proc. SPIE-Int. Soc. Opt. Eng., 1203: 266-80.

Due to the importance of photodynamic therapy in the treatment of cancer, there is a continuing need to identify new photosensitizer formulations that are stable, exhibit ease in manufacturing and which selectively deliver the photosensitizer, particularly the more hydrophobic photosensitizers, to the target tissue in an efficient manner.

SUMMARY OF THE INVENTION

The present invention involves a freeze dried pharmaceutical formulation comprising a porphyrin photosensitizer, a disaccharide or polysaccharide, and one or more phospholipids, which freeze-dried formulation forms liposomes containing a therapeutically effective amount of the porphyrin photosensitizer upon reconstitution with a suitable aqueous vehicle. The invention also relates to the liposome composition formed upon reconstitution with said aqueous vehicle.

The porphyrin photosensitizers usable in the practice of this invention include any of the known porphyrin derivative compounds useful in photodynamic therapy characterized in that they contain a porphyrin ring system. These include deuteroporphyrin, etioporphyrin, protoporphyrin, hematoporphyrin, pheophorbide and derivatives thereof. Particularly useful are hematoporphyrin and derivatives thereof as described in U.S. patents 4,649,151, 4,866,168, 4,889,129 and 4,922,934. The most preferred porphyrin photosensitizers usable in the present invention are the (Gp) having a light absorption maximum between 670-780 nm wherein the Gp is selected from the group consisting of those compounds having the formulae set forth in Figure 1 and mixtures thereof and the metalated and labeled forms thereof;

wherein each R^1 and R^2 is independently selected from the group consisting of carbalkoxy (2-6C), alkyl (1-6C) sulfonyl, aryl (6-10C) sulfonyl,

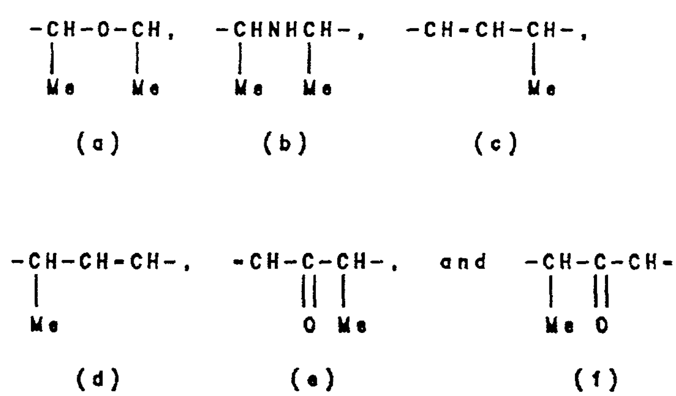
aryl (6-10C); cyano; and $-CONR^5CO-$ wherein R^5 is aryl (6-10C) or alkyl (1-6C);

each R^3 is independently carboxyalkyl (2-6C) or a salt, amide, ester or acylhydrazone thereof, or is alkyl (1-6C); and

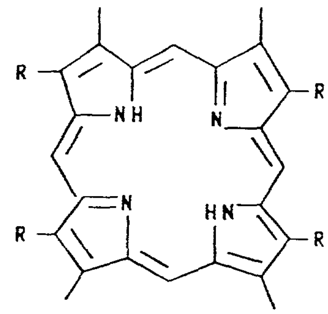
R^4 is $CHCH_2$, $CHOR^{4'}$, $-CHO$, $-COOR^{4'}$, $CH(OR^{4'})CH_3$, $CH(OR^{4'})CH_2OR^{4'}$, $-CH(SR^{4'})CH_3$, $-CH(NR^{4'}_2)CH_3$, $-CH(CN)CH_3$, $-CH(COOR^{4'})CH_3$, $-CH(OOCR^{4'})CH_3$, $-CH(halo)CH_3$, or $-CH(halo)CH_2(halo)$, wherein $R^{4'}$, is H, alkyl (1-6C) optionally substituted with a hydrophilic substituent, or

wherein R^4 is an organic group of <12C resulting from direct or indirect derivatization of vinyl, or

wherein R^4 consists of 1-3 tetrapyrrole-type nuclei of the formula -L-P wherein -L- is selected from the group consisting of



and P is selected from the group consisting of Gp which is of the formula 1-6 but lacking R^4 and conjugated through the position shown as occupied by R^4 to L, and a porphyrin of the formula:



wherein each R is independently H or lower alkyl (1-4C);

wherein two of the bonds shown as unoccupied on adjacent rings are joined to R^3 and one of the remaining bonds shown as unoccupied is joined to R^4 and the other to L;

with the proviso that if R^4 is $CHCH_2$, both R^3 cannot be carbalkoxyethyl.

The preparation and use of such compounds is disclosed in U.S. patent 4,920,143, and 4,883,790 hereby incorporated by reference. The most preferred compounds of the hydro-monobenzoporphyrins recited above are the compounds of formulas 3 and 4 designated benzoporphyrin derivative (BPD) which have the formulas set forth in Figure 2. These are hydrolyzed or partially hydrolyzed forms of the rearranged products of formula 3 or 4, wherein one or both of the protected carboxyl groups of R^3 are hydrolyzed. Particularly preferred is the compound referred to as BPD-MA in Figure 2.

The liposomes of the present invention possess certain attributes which make them particularly suited for delivering the porphyrin photosensitizers. Conventional liposomal formulations are preferentially taken up by the reticuloendothelial system (RES) organs such as the liver and spleen. When this occurs, the major portion of the liposomal encapsulated water

insoluble drug is not available to tumor sites since it is localized in the RES. In contrast, the liposomes formed in the present invention are "fast breaking" in that the drug-liposome combination is stable *in vitro* but when administered *in vivo*, the photosensitizer is rapidly released into the bloodstream where it associates with serum lipoproteins. It is believed that this inhibits the drug from being accumulated in non-target tissues such as the liver, where liposomes otherwise have a tendency to concentrate. The "fast breaking" nature of the present liposomes may be due to the manner in which the porphyrin photosensitizer associates with the lipid bilayer of the liposomes of the present invention.

In addition, the particular combination of a disaccharide or polysaccharide and one or more phospholipids forms a liposomal formulation which gives liposomes which exhibit excellent reproducibility in terms of particle size. Reproducibility and narrow particle size distribution of the liposomal solution upon reconstitution with water is enhanced by an increased speed of hydration since a delay in hydration results in larger liposomes or precipitation of the drug. The addition of the disaccharide or polysaccharide provides instantaneous hydration and the largest surface area for depositing a thin film of the drug-phospholipid complex. This thin film provides for faster hydration so that when the liposome is formed by adding the aqueous phase, the liposomes formed are of sufficiently small and uniform particle size such that the composition can be sterile filtered without any pre-filtering or separation of components with larger particle size. This provides significant advantages in terms of manufacturing ease. In addition, the present liposomes provide 80-100% encapsulations of a drug which is expensive and requires a complicated synthetic

procedure to produce. Thus, there is no reworking necessary and very little waste of the drug.

Disaccharides or polysaccharides are preferred to monosaccharides. To keep the osmotic pressure of the liposome formulation similar to blood, no more than 4-5% monosaccharides can be added. In contrast, the same osmotic pressure can be generated with 9-10% of a disaccharide. This higher amount of disaccharide provides for the larger surface area which leads to the smaller particle size when the lyophilyzed liposomes are reconstituted.

The preferred liposomal formulation of the present invention for incorporation of porphyrin photosensitizers comprise a disaccharide or polysaccharide, and one or more phospholipids which may be a phosphatidyl choline and a phosphatidyl glycerol. The disaccharide or polysaccharide are preferably chosen from lactose, trehalose, maltose, maltrotriose, palatinose, lactulose or sucrose.

The preferable phospholipids are phosphatidyl cholines such as dimyristoyl phosphatidyl choline (DMPC), phosphatidyl choline (PC), dipalmitoylphosphatidy choline (DPPC), distearoylphosphatidyl choline (DSPC), soy phosphatidyl choline or egg phosphatidyl choline. The preferable phosphatidyl glycerols are dimyristoylphosphatidylglycerol (DMPG), and egg phosphatidylglycerol (EPG). Other phospholipids that may be incorporated in the liposomes of the present invention are phosphatidyl ethanolamine, phosphatidic acid, phosphatidylserine and phosphatidylinositol. More preferably the liposomes comprise lactose, dimyristoylphosphatidyl choline (DMPC) and egg phosphatidylglycerol (EPG). The disaccharide or polysaccharide and phospholipid are formulated in a preferred ratio of about 10-20 to 0.5-6, respectively, most preferably 10 to 1.5-4.0.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages will occur from the following descriptions of preferred embodiments and the accompanying drawings in which;

Figure 1 shows the structure of green porphyrin (Gp) compounds used in the liposomal formulations of the invention.

Figure 2 shows the structure of four preferred forms of the hydro-monobenzoporphyrin derivatives of formulas 3 and 4 (BPDs).

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a pharmaceutical liposome formulation of a porphyrin photosensitizer for use in the photodynamic therapy or diagnosis of tumors, or for a variety of other therapeutic applications. The liposomes are formed upon addition of an aqueous vehicle to a freeze-dried formulation of a porphyrin photosensitizer, a disaccharide or polysaccharide, and one or more phospholipids such as phosphatidyl cholines or phosphatidyl glycerols. The presence of the disaccharide or polysaccharide in the formulation yields liposomes which have extremely small and narrow particle size, in which the porphyrin photosensitizers may be stably incorporated into the liposome in an efficient manner with encapsulation efficiency approaching 80-100% of the drug. The liposomes exhibit physical and chemical stability such that they retain incorporated porphyrin drugs without leakage upon prolonged storage, as either a reconstituted liposomal suspension or cryodesiccated powder. For example, BPD-MA, a preferred porphyrin photosensitizer, maintained its potency in the cryodesiccated liposome formulation for a period of at least nine months at room temperature and had a projected shelf life of at least two years.

The class of porphyrin photosensitizers preferably utilized in the present invention are the hydro-monobenzoporphyrins (GP) disclosed in U.S. Patents 4,920,143 and 4,883,790, and most preferably the compounds designated benzoporphyrin derivative (BPD), particularly BPD-MA having the formula set forth in Figure 2.

Liposomes containing a selected porphyrin photosensitizer as described herein may be prepared by dissolving the porphyrin photosensitizer, the phospholipids and other optional adjuvants such as antioxidants in methylene chloride or other suitable organic solvents. The resulting solution is dried under vacuum until the organic solvent is evaporated. The solid residue is dispersed in an aqueous solution of the disaccharide or polysaccharide and homogenized. The solution is then freeze dried for storage and reconstituted prior to administration with a suitable aqueous vehicle such as sterile water for injection. Upon reconstitution, liposomes are formed which incorporate a therapeutically effective amount of the porphyrin photosensitizer.

The liposomal formulation of the present invention provides liposomes of sufficiently small and narrow particle size such that it can be manufactured without filtering to separate off larger particles or utilizing other mechanical methods of obtaining a narrow distribution of particle size.

As noted, the preferred phospholipids are the phosphatidyl cholines such as dimyristoyl phosphatidyl choline (DMPC), phosphatidyl choline (PC), dipalmitoyl-phosphatidyl choline (DPPC) and distearoylphosphatidyl choline (DSPC) with DMPC being preferred. The preferred phosphatidyl glycerols are dimyristoyl phosphatidylglycerol (DMPG) and egg phosphatidyl-glycerol (EPG) with DMPG being preferred. The

preferred disaccharides or polysaccharides are lactose, trehalose, maltose, maltotriose, palatinose, lactulose or sucrose with lactose or trehalose being most preferred. The disaccharide and phospholipids are formulated in a preferred ratio of about 10-20 to 0.5-6 respectively, most preferably 10 to 1.5-4.0.

A preferable but not limiting formulation is lactose or trehalose, dimyristoyl phosphatidyl choline and egg phosphatidyl glycerol in a concentration ratio of 10 to 0.94-1.88 to 0.65-1.30, respectively.

Other optional ingredients in the liposomal formulation are antioxidants such as butylated hydroxytoluene, α-tocopherol and ascorbyl palmitate.

The use of these porphyrin photosensitizers incorporated in liposomes for the treatment or diagnosis of cancer is described herein as a new effective treatment or therapeutic method. The liposomal formulations are useful in sensitizing neoplastic cells or other abnormal tissue including infectious agents to destruction by exposure to light using preferably, visible light. Upon photoactivation, the porphyrin photosensitizer promote the formation of singlet oxygen which is responsible for the cytotoxic effect. In addition, the porphyrin photosensitizers, when photoactivated, will fluoresce when subjected to appropriate excitation wavelengths. This fluorescence can be used to localize the tumor or other target tissue. By incorporating the porphyrin photosensitizer in the liposomes of the present invention, more efficient sensitization of tumor tissues can be obtained.

Generally speaking, the concentration of the porphyrin photosensitizer in the liposome depends upon the nature of the photosensitizer used. When the benzoporphyrin derivatives such as BPD-MA are used, the photosensitizer is incorporated in the liposomes at a

concentration of about 0.10% up to 0.5% w/v, yielding a reconstituted solution of up to 5.0 mg/ml.

Such liposomes are typically administered parenterally. Injection may be intravenous, subcutaneous, intramuscular, intrathecal, or even intraperitoneal. The liposomes could be administered by aerosol intranasaly or intrapulmonarily. The freeze dried powder may be packed in vials for reconstitution with sterile water prior to injection. Of course, these compositions may also contain minor amounts of nontoxic, auxiliary substances such as pH buffering agents and the like.

The quantity of photosensitizer liposome formulations to be administered depends on the choice of active ingredients, the conditions to be treated, the mode of administration, the individual subject and the judgement of the practitioner. Generally speaking, dosages in the range of 0.05-10 mg/kg may be needed. The foregoing range is of course merely suggestive, as the number of variables in regard to an individual treatment regime is large and considerable excursions from these recommended values are expected.

For use as a diagnostic in localizing tumor tissue or in localizing atherosclerotic plaques, the compounds or conjugates of the invention are administered systemically in the same general manner as is known with respect to photodynamic therapy. The waiting period to allow the drugs to clear from tissues to which they do not accumulate is approximately the same, about 30 minutes to 10 hours. After the compounds of the invention or their conjugates have been permitted to localize, the location of the target tissue is determined by detecting the presence of the drug.

For diagnosis, the compounds incorporated in the liposomes may be used along with, or may be labeled

with, a radioisotope or other detecting means. If this is the case, the detection means depends on the nature of the label. Scintigraphic labels such as technetium or indium can be determined using ex vivo scanners. Specific fluorescent labels can also be used, but these require prior irradiation, as does the detection based on fluorescence of the compounds of the invention themselves.

For activation of the photosensitizer of the invention, any suitable absorption wavelength is used. This can be supplied using the various methods known to the art for mediating cytotoxicity or fluorescence emission, such as visible radiation, including incandescent or fluorescent light sources or photodiodes, such as light emitting diodes. Laser light is also used for in situ delivery of light to the localized photosensitizer. In a typical protocol, several hours before irradiation, approximately 0.5-1.5 mg/kg of the green porphyrin is injected intravenously and then excited by an appropriate wavelength.

The methods of preparation of liposomal porphyrins of the present invention and photodynamic treatment therewith described in the Examples contained later herein are readily adapted to the production and use of analogously described liposomes by simple substitutions of appropriate porphyrins, phospholipids or methods.

Either unilamellar or multilamellar or other types of liposomes may be used in the practice of the present invention. They may be prepared in a suspension form or may be formed upon reconstitution of a lyophilized powder containing the porphyrin - phospholipid - saccharide composition with an aqueous solution.

These following examples are presented to describe preferred embodiments, utilities and

attributes of the present invention but are not meant to limit the invention. For example, although DMPC and EPG were used to form liposomes, these particular phospholipids are by no means the only available usable lipid forms known to those skilled in the art. Nor do the particular methods of forming or preparing the liposomes described herein constitute the only methods for preparing liposomes contemplated by the present invention. Moreover, although the examples imply the photosensitizer BPD-MA, the procedures, results and preparations should be similar for other porphyrin photosensitizers.

EXAMPLE 1

PREPARATION OF LIPOSOMES CONTAINING BPD-MA

BPD-MA was synthesized as described in U.S. Patent 4,920,143 and 4,883,790, incorporated herein by reference. Liposomes were prepared according to the following general procedure:

BPD-MA, butylated hydroxytoluene, ascorbyl palmitate and the phospholipids are dissolved in methylene chloride and the solution is filtered through a 0.22 micron filter. The solution is then dried under vacuum using a rotary evaporator until the methylene chloride level in the solid residue is not detectable by gas chromatography. A 10% lactose/water for injection solution is then prepared and filtered through a 0.22 micron filter. The lactose/water solution is warmed to about 35°C and added to the flask containing the solid residue of the photosensitizer/-phospholipid. The solid residue is dispersed in the 10% lactose/water solution and stirred for about one hour, cooled, and passed through a homogenizer. The solution is then filtered through a 0.22 micron Durapore® hydrophilic filter. Optionally, the solution may first be prefiltered with a 5.0 micron prefilter. The filtrate is collected, filled into vials and freeze dried and stored under refrigeration. The freeze dried composition is reconstituted with water for injection prior to administration.

Using the foregoing procedure, several different preparations of the BPD-MA liposomal composition were prepared as follows:

EXAMPLE 1A

Preparation of a Liposomal Drug Delivery System Containing BPD-MA up to 4.0 mg/ml

Ingredient	Amount % w/v
- BPD-MA	0.2 to 0.4
- Dimyristoyl Phosphatidyl Choline	0.94 to 1.88
- Egg Phosphatidyl Glycerol	0.65 to 1.30
- Lactose or Trehalose	8.0 to 12.0
- Ascorbyl Palmitate	0.002 to 0.004
- Butylated Hydroxy Toluene	0.0002 to 0.0004
- Water for Injection	Q.S.

EXAMPLE 1B

Preparation of a Liposomal Drug Delivery System Containing BPD-MA up to 3.0 mg/ml

Ingredient	Amount % w/v
- BPD-MA	0.2 to 0.3
- Dimyristoyl Phosphatidyl Choline	1.7 to 2.6
- Soy Phosphatidyl Choline	2.3 to 3.5
- Lactose or Trehalose	8.0 to 12.0
- Ascorbyl Palmitate	0.002 to 0.003
- Butylated Hydroxy Toluene	0.0002 to 0.0003
- Water for Injection	Q.S.

EXAMPLE 1C

Preparation of a Liposomal Drug Delivery System Containing BPD-MA up to 5.0 mg/ml

Ingredient	Amount % w/v
- BPD-MA	0.2 to 0.5
- Phosphatidyl Ethanolamine	1.0 to 2.5
- Egg Phosphatidyl Choline	0.7 to 1.75
- Lactose or Trehalose	8.0 to 12.0
- Ascorbyl Palmitate	0.002 to 0.005
- Butylated Hydroxy Toluene	0.0002 to 0.0005
- Water for Injection	Q.S.

EXAMPLE 1D

Preparation of a Liposomal Drug Delivery System Containing BPD-MA up to 4.0 mg/ml

Ingredient	Amount % w/v
- BPD-MA	0.2 to 0.4
- Dimyristoyl Phosphatidyl Choline	1.13 to 2.26
- Phosphatidic Acid	0.43 to 0.86
- Lactose or Trehalose	8.0 to 12.0
- Ascorbyl Palmitate	0.002 to 0.004
- Butylated Hydroxy Toluene	0.0002 to 0.0004
- Water for Injection	Q.S.

EXAMPLE 1E

Preparation of a Liposomal Drug Delivery System Containing BPD-MA up to 1.0 mg/ml

Ingredient	Amount % w/v
- BPD-MA	0.1
- Egg Phosphatidyl Choline	0.55
- Egg Phosphatidyl Glycerol	0.32
- Lactose	8.0 to 12.0
- Ascorbyl Palmitate	0.002
- Butylated Hydroxy Toluene	0.0002
- Water for Injection	Q.S.

EXAMPLE 1F

Ingredient	Amount % w/v
- BPD-MA	0.2 to 0.3
- Dimyristoyl Phosphatidyl Choline	1.1 to 1.6
- Phosphatidic Acid	0.4 to 0.7
- Lactose or Trehalose	8.0 to 12.0
- Ascorbyl Palmitate	0.002 to 0.005
- Butylated Hydroxy Toluene	0.0002 to 0.0005
- Water for Injection	Q.S.

EXAMPLE 2

PHYSICAL AND CHEMICAL STABILITY OF LIPOSOMAL BPD-MA

The physical stability of the liposomal BPD-MA was assessed by monitoring the particle size distribution and osmolarity of the reconstituted solution over time when stored at various temperatures. In all cases the mean particle size distribution was less than 200nm. Osmolarity also showed no significant difference. The results are shown in Table 1. The data supports the physical stability of this dosage form.

TABLE I

Stability of Liposomal BPD-MA for Injection 25 mg/vial

	Mean Particle Size Distribution nm	Osmolarity mosm/kg
Initial	170	295
3°C- 1 Month	168	287
3°C- 3 Month	157	291
3°C- 6 Month	189	281
23°C- 1 Month	147	308
23°C- 3 Month	155	291
23°C- 6 Month	172	285
30°C- 1 Month	169	305
30°C- 3 Month	134	291
30°C-75%RH 1 Month	155	287
30°C-75%RH 3 Month	132	294
Light Cabinet 0.25 Month		300

The chemical stability of the constituted dosage form was followed by monitoring the potency, degradation products and pH of the reconstituted solution. The potency of the reconstituted parenteral dosage form was assessed by chromatography with potency calculated on as is basis. The potency of the cryodesiccated powder showed a slight change from initial up to six month period at 3 or 23°C with data ranging from 100.0 - 98.2 percent of labeled claims. The results are shown in Table II.

TABLE II

Stability of Liposomal BPD-MA for Injection 25 mg/vial

	Potency Assay BPD-MA mg/vial	Potency Assay BPD-MA 0/0 Label	Degradation Product HPLC Area 0/0	pH
Initial	25.1	100.4	0.82	6.8
$3^{o}C$- 1 Month	25.0	100.0	0.81	6.4
$3^{o}C$- 3 Month	25.1	100.4	0.72	6.4
$3^{o}C$- 6 Month	24.7	98.8	0.80	6.4
$23^{o}C$- 1 Month	25.3	101.2	0.83	6.4
$23^{o}C$- 3 Month	25.0	100.0	0.85	6.4
$23^{o}C$- 6 Month	24.7	98.6	0.80	6.2
$30^{o}C$- 1 Month	25.2	100.8	0.83	6.3
$30^{o}C$- 3 Month	25.1	100.2	0.85	6.3
$30^{o}C$-75%RH 1 Month	25.2	100.8	0.80	6.3
$30^{o}C$-75%RH 3 Month	24.6	98.4	0.80	6.3
Light Cabinet 0.25 Month	24.6	98.2	0.98	6.4

EXAMPLE 3

Distribution of Liposomal BPD-MA in Human Blood

The liposomal BPD-MA of the present invention was incubated in human blood for varying time periods and analyzed to determine the distribution of the drug to various blood compartments.

Table III shows the comparison of the distribution of liposomal ^{14}C-BPD-MA (formulated) and ^{14}C-BPD-MA in DMSO (non-formulated) between plasma and whole blood cells. ^{14}C-BPD-MA at 25 ug/ml was incubated with whole blood at 4°C.

Table IV shows the distribution of liposomal ^{14}C-BPD-MA in plasma after 1, 6 and 24 h incubation. Rudel's density gradient ultracentrifugation was used to obtain fractions. Radioactivity is expressed as a percentage of total radioactivity in the plasma (mean ± S.D.) n=2).

Table V shows the distribution of ^{14}C-BPD-MA in DMSO (expressed as % of total radioactivity) between human plasma fractions obtained by Rudel's density gradient centrifugation, following 1 and 24 h incubation. Each value represents mean ± S.D. (n=3).

The results shown in the following Tables III, IV and V demonstrate the "fast breaking" nature of the liposomal formulation of the present invention. As shown above the active drug associates rapidly with the lipoprotein compartment of the blood which in turn acts as a circulating reservoir of the drug.

TABLE III

Time(h)	% of Total Counts			
	Plasma		Red and White Blood Cells	
	Liposomal	DMSO Solution	Liposomal	DMSO Solution
1	86.3	92.5	13.7	7.5
6	94.1	-	5.9	-
24	88.7	84.0	11.3	16.0

TABLE IV

Fraction	Composition	% of Total DPM		
		1 h	6 h	24 h
1 + 2	lipoproteins	91.1 ± 0.9	89.8 ± 0.9	90.4 ± 4.9
3	salt & water	1.8 ± 0.5	2.5 ± 0.4	0.9 ± 0.2
4	albumin	6.6 ± 0.1	5.3 ± 2.3	6.5 ± 0.1
5	other proteins	0.6 ± 0.2	2.6 ± 3.0	2.4 ± 2.2

TABLE V

Fraction	Composition	% Total DPM	
		1 hour	24 hours
1 + 2	lipoproteins	49.1 ± 2.6	86.7 ± 2.2
3	salt & water	13.1 ± 2.0	7.41 ± 0.8
4	albumin	35.9 ± 0.1	4.9 ± 2.9
5	other plasma proteins	1.8 ± 1.0	1.1 ± 0.1

EXAMPLE 4

ANTITUMOR ACTIVITY OF LIPOSOMAL BPD-MA

Dose-response curves of liposomal benzoporphyrin derivative monoacid (BPD-MA) were obtained by exposing tumor-bearing mice treated with various doses of drug to 150 J/cm^2 of 690 nm laser light. The results indicated an ED_{50} in the region of 1.5 mg/kg.

DBA/2 male mice carrying M1-S tumors were shaved and depilated at least 24 hours prior to treatment. Liposomal BPD-MA was injected i.v., and after a 3 hour waiting period, during which time the animals were kept in the dark, the tumor site was exposed to 150 J/cm^2 of 690 nm light from an argon ion pumped dye laser. The animals were then returned to the cage, and observed over the next 20 days.

Dose Groups	Animals
BPD-MA 0 mg/kg	2 X 10
BPD-MA 0.5 mg/kg	2 X 10
BPD-MA 1.0 mg/kg	2 X 10
BPD-MA 1.5 mg/kg	2 X 10
BPD-MA 2.0 mg/kg	2 X 10

Two series of experiments were carried out, each consisting of 5 groups of animals treated with 0, 0.5, 1.0, 1.5, or 2.0 mg/kg liposomal BPD-MA. (See Table VI)

100% of the animals at the 2 mg/kg dose point were tumor-free at day 7 in both series I and II. By day 14, 30% of the tumors recurred in series I, and 20% in series II, and by day 20, 60% of the mice were tumor positive in series I and 30% in series II.

At the 1.5 mg/kg point, 70% of the animals in series I and 80% in series II were tumor-free at Day 7, 30% in both series were tumor-free at Day 14, and 10% and 20% were tumor-free at Day 20.

The 1.0 mg/kg dose points in the two series were dissimilar in that 40% of the animals were tumor-free at day 7 in series I, 20% at day 14, and 10% at Day 20. In series II, 90% of the animals were tumor-free at day 7, 40% at day 14 and 30% at day 20.

No effect was noted at either the 0.5 mg/kg or the 0 mg/kg dose points. The tumors continued to grow at the normal rate.

The disparity between the two series at the 1.0 mg/kg dose point makes it difficult to determine an ED_{50}. However, at this time we can deduce that the ED_{50} will lie in the region of 1.5 mg/kg.

The following Table VI provides the number of animals remaining tumor free at Day 7, 14 and 20 after treatment with varying doses of liposomal BPD-MA and 150 J/cm^2 690 nm laser light.

TABLE VI

Series I	Drug Dose	# Animal	D7	D14	D20
	0.0 mg/kg	10	0	-	-
	0.5 mg/kg	10	0	-	-
	1.0 mg/kg	10	4	2	1
	1.5 mg/kg	10	7	3	1
	2.0 mg/kg	10	10	7	4
Series II	**Drug Dose**	**# Animal**	**D7**	**D14**	**D20**
	0.0 mg/kg	10	0	-	-
	0.5 mg/kg	10	0	-	-
	1.0 mg/kg	10	9	4	3
	1.5 mg/kg	10	8	3	2
	2.0 mg/kg	10	10	8	7

We claim:

1. A freeze dried pharmaceutical formulation comprising a porphyrin photosensitizer, a disaccharide or polysaccharide, and one or more phospholipids which formulation, upon addition of a suitable aqueous vehicle, forms liposomes containing a therapeutically acceptable amount of said porphyrin photosensitizer.

2. A pharmaceutical liposomal formulation formed upon addition of a suitable aqueous vehicle to the freeze-dried formulation according to claim 1.

3. A pharmaceutical formulation according to claim 1 wherein said formulation comprises a porphyrin photosensitizer, a disaccharide or polysaccharide, a phosphatidyl choline and a phosphatidyl glycerol.

4. A pharmaceutical formulation according to claim 1 or 3 wherein said disaccharide or polysaccharide is selected from lactose or trehalose.

5. A pharmaceutical formulation according to claims 1, 3 or 4 wherein the concentration ratio of disaccharide or polysaccharide to phospholipid is about 10-20 to 0.5-6.

6. A pharmaceutical formulation of claims 1, 2, 3, 4 or 5 wherein said porphyrin photosensitizer is a hydro-monobenzoporphyrin (Gp) of the formulae set forth in Figure 1 having a light absorption maximum between 670-780 nm;
and mixtures thereof and the metalated and labeled forms thereof,

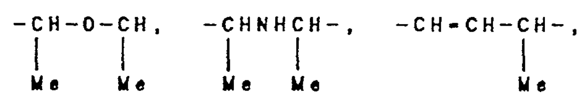
wherein each R^1 and R^2 is independently selected from the group consisting of carbalkoxy (2-6C), alkyl (1-6C) sulfonyl, aryl (6-10C) sulfonyl, aryl (6-10C); cyano; and $-CONR^5CO-$ wherein R^5 is aryl (6-10C) or alkyl (1-6C);

each R^3 is independently carboxyalkyl (2-6C) or a salt, amide, ester or acylhydrazone thereof, or is alkyl (1-6C); and

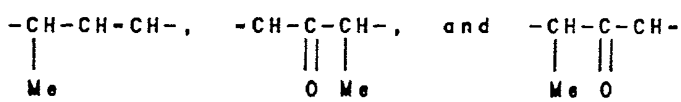
R^4 is $CHCH_2$, $CHOR^{4'}$, -CHO, $-COOR^{4'}$, $CH(OR^{4'})CH_3$, $CH(OR^{4'})CH_2OR^{4'}$, $-CH(SR^{4'})CH_3$, $-CH(NR^{4'}{}_2)CH_3$, $-CH(CN)CH_3$, $-CH(COOR^{4'})CH_3$, $-CH(OOCR^{4'})CH_3$, $-CH(halo)CH_3$, or $-CH(halo)CH_2(halo)$, wherein $R^{4'}$, is H, alkyl (1-6C) optionally substituted with a hydrophilic substituent, or

wherein R^4 is an organic group of less than 12C resulting from direct or indirect derivatization of vinyl, or

wherein R^4 consists of 1-3 tetrapyrrole-type nuclei of the formula -L-P wherein -L- is selected from the group consisting of

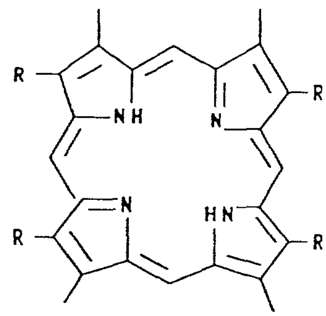


(a) (b) (c)



(d) (e) (f)

and P is selected from the group consisting of Gp which is of the formula 1-6 but lacking R^4 and conjugated through the position shown as occupied by R^4 to L, and a porphyrin of the formula:



wherein each R is independently H or lower alkyl (1-4C);

wherein two of the bonds shown as unoccupied on adjacent rings are joined to R^3 and one of the remaining bonds shown as unoccupied is joined to R^4 and the other to L;

with the proviso that if R^4 is $CHCH_2$, both R^3 cannot be carbalkoxyethyl.

7. The formulation of claim 6 wherein each R^3 is $-CH_2CH_2COOH$ or salt, amide, ester or acylhydrazone thereof.

8. The formulation of claim 6 wherein each of R^1 and R^2 is carbalkoxy (2-6C).

9. The formulation of claim 7 wherein each of R^1 and R^2 is carbalkoxy (2-6C).

10. The formulation of claim 7 wherein the Gp has the formula 3 or 4 of Figure 2.

11. The formulation of claim 9 wherein the Gp has the formula 3 or 4 of Figure 2.

12. A pharmaceutical formulation according to claim 1 further containing an antioxidant.

13. A pharmaceutical formulation according to claim 1 in association with a pharmaceutically acceptable adjuvant or excipient.

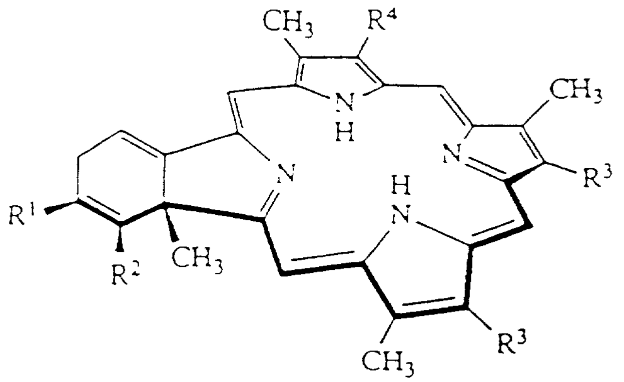
14. The formulation of claims 1 or 2 wherein the therapeutically effective concentration of the

porphyrin photosensitizer is between about 0.10 to 0.50 percent w/v.

LIPOSOME COMPOSITIONS OF PORPHYRIN PHOTOSENSITIZER

ABSTRACT

Liposomal pharmaceutical formulations incorporating porphyrin photosensitizers useful for photodynamic therapy or diagnosis of malignant cells. The liposomal formulations comprise a porphyrin photosensitizer, particularly the hydro-mono benzoporphyrins (BPD) having light absorption maxima in the range of 670-780 nanometers, a disaccharide or polysaccharide and one or more phospholipids.



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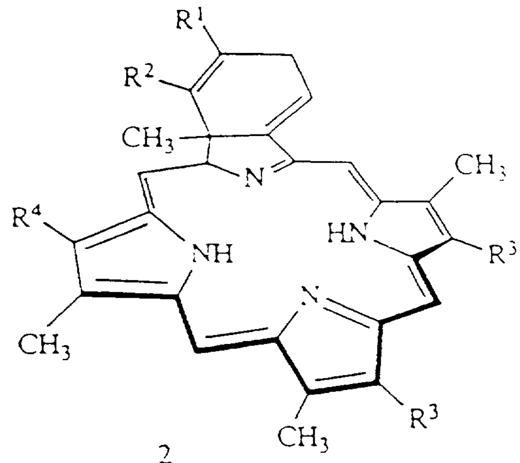

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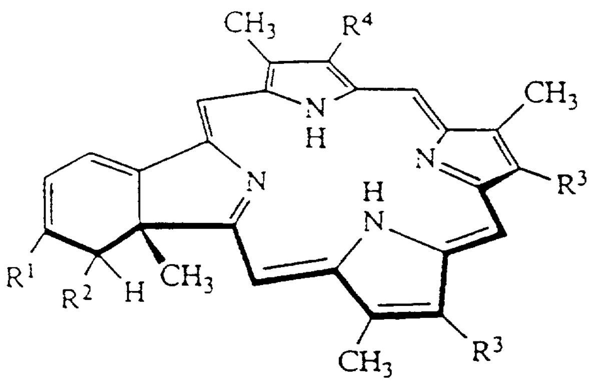

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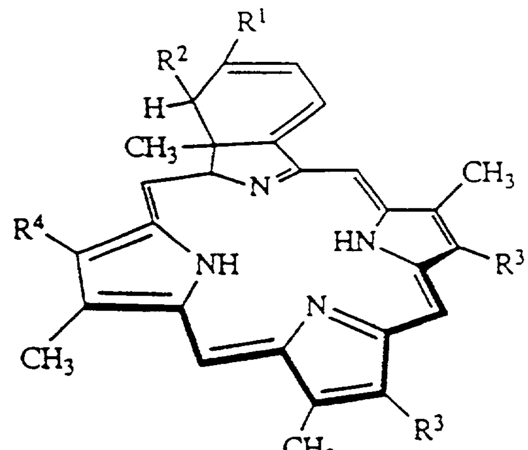

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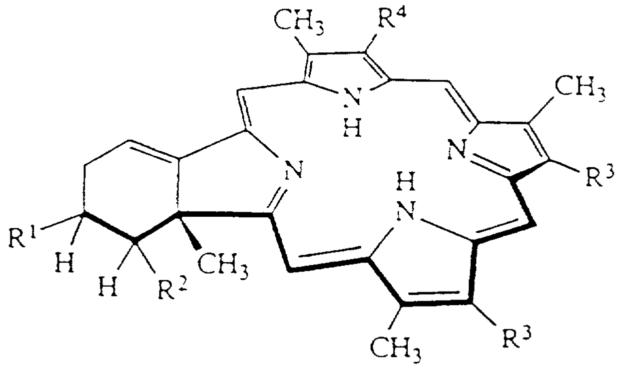
FIGURE 1-1



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or

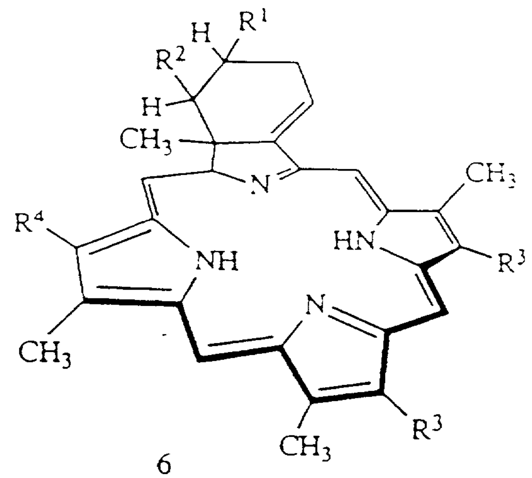

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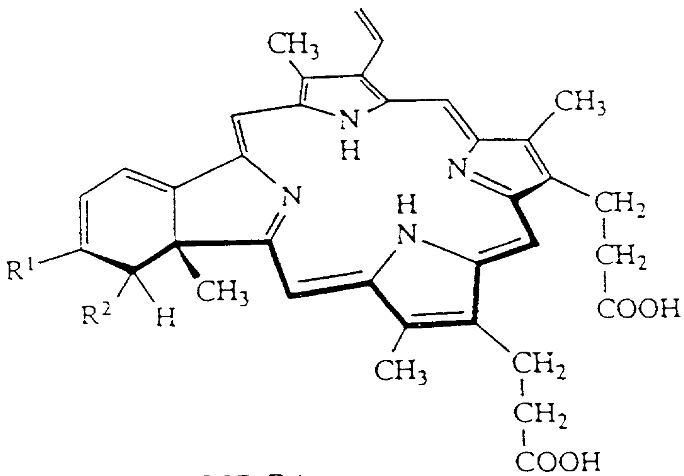
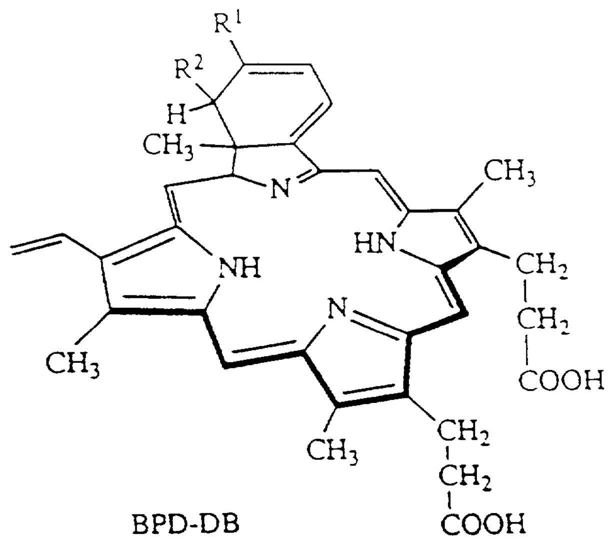
FIGURE 1-2

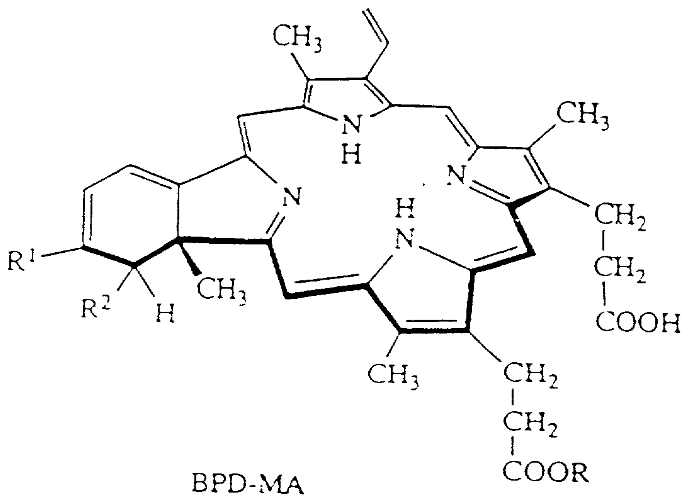


BPD-DA



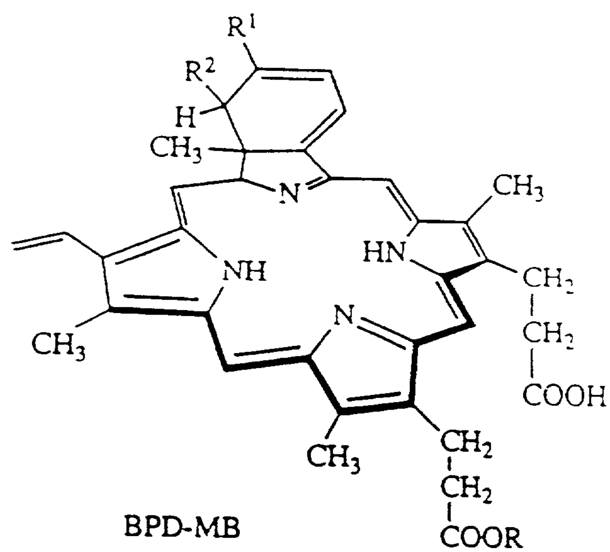
BPD-DB

FIGURE 2-1



BPD-MA

and



BPD-MB

FIGURE 2-2

[REV.4Apr89/MB1-1] Docket No. 31,812-00

PATENT

COMBINED DECLARATION AND POWER OF ATTORNEY

(Original,Design,Supplemental,Divisional,Continuation,CIP)

As the below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type:

[X] original
[ ] design
[ ] supplemental
[ ] divisional
[ ] continuation
[ ] continuation-in-part (CIP)

INVENTORSHIP IDENTIFICATION

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural named are listed below) of the subject matter which is claimed for, for which a patent is sought on the invention entitled:

TITLE OF INVENTION

LIPOSOME COMPOSITIONS OF PORPHYRIN PHOTOSENSITIZERS

SPECIFICATION IDENTIFICATION

the specification of which: (complete (a), (b), or (c))

(a) [X] is attached hereto.

(b) [ ] was filed on ______________ as

[ ] Serial Number /

[ ] Express Mail No., as Serial Number not yet known

(c) [ ] was described and claimed in PCT International Application No. ______________ filed on ______________ and as amended under PCT Article 19 on ______________ (if any).

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37 CFR 1.97.

PRIORITY CLAIM

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate or of any PCT International application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate of any PCT International application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(d) [X] no such applications have been filed.

(e) [ ] such applications have been filed as follows.

Note: Where item (c) is entered above and the International Application which designated the U.S. claimed priority check item (e), enter the details below and make the priority claim.

Earliest Foreign Application(s), if any, filed within 12 months (6 months for Design) prior to this U.S. Application

COUNTRY	APPLICATION NUMBER	DATE OF FILING (DAY,MONTH,YEAR)	PRIORITY CLAIMED 35 USC 119

All Foreign Application(s), if any, Filed More Than 12 Months (6 Months for Design) Prior to This U.S. Application

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

(Name)	(Reg. No.)
Kenneth J. Dow	32,890
Robert P. Raymond	25,089
H. G. Jackson	24,476
Thomas S. Szatkowski	28,049

[ ] Attached as part of this declaration and power of attorney is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

SEND CORRESPONDENCE AND TELEPHONE CALLS TO:
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1937 West Main Street
P. O. Box 60
Stamford, Ct 06904-0060
Attn: Kenneth J. Dow
Telephone No. (203) 321-2659

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

Full name of SOLE OR FIRST INVENTOR Narendra Raghunathji Desai

Inventor's signature Narendra Raghunathji Desai
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Country of Citizenship India
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Post Office Address Same as above

Full name of SECOND JOINT INVENTOR, if any Bushra J. Agha

Inventor's signature Bushra J. Agha
Date 2/2/92
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Post Office Address Same as above

Full name of THIRD JOINT INVENTOR, if any Kalidas Madhavrao Kale

Inventor's signature x Kalidas Madhavarao Kale.
Date 1-31-92
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THE FOLLOWING 'ADDED PAGES' FORM A PART OF THIS DECLARATION

[X] Signature for fourth and subsequent joint inventors on ADDED PAGES.

[ ] ADDED PAGES TO COMBINED DECLARATION, POWER OF ATTORNEY for divisional, continuation, or continuation-in-part (CIP) application.

[X] Number of ADDED PAGES: 1

[ ] Declaration ends with this page.

ADDED PAGE TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR SIGNATURE BY FOURTH AND SUBSEQUENT INVENTORS

Full name of FOURTH JOINT INVENTOR, if any James R. Lawter

Inventor's signature ____________________

Date 31/92

Country of Citizenship U.S.A.

Residence 35 Glen Drive, Goshen, NY 10924

Post Office Address Same as above

Full name of FIFTH JOINT INVENTOR, if any ____________________

Inventor's signature ____________________

Date ____________________

Country of Citizenship ____________________

Residence ____________________

Post Office Address ____________________

Full name of SIXTH JOINT INVENTOR, if any ____________________

Inventor's signature ____________________

Date ____________________

Country of Citizenship ____________________

Residence ____________________

Post Office Address ____________________

Full name of SEVENTH JOINT INVENTOR, if any ____________________

Inventor's signature ____________________

Date ____________________

Country of Citizenship ____________________

Residence ____________________

Post Office Address ____________________